LA-UR- 02-5151

Approved for public release;
distribution is unlimited.

Title: Light Transmission and Air used for Inspection of Glovebox Gloves

Author(s): Julio M. Castro, 088888, HSR-1
Warren P. Steckle Jr., 113467, MST-7
John M. Macdonald, 107889, NMT-10

Submitted to: American Glovebox Society
Conference, August 19-21, 2002
9700 International Drive,
Orlando, Florida 32819
Rosen Plaza Hotel

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory

Julio M. Castro
Health, Safety and Radiation Protection, HSR-1

Warren P. Steckle Jr.
Material, Science and Technology, MST-7

Kennard V. Wilson Jr.
Material, Science and Technology, MST-7

John M. Macdonald
Process Engineering, NMT-13

Light Transmission and Air used for Inspection of Glovebox Gloves

Abstract
An analysis was conducted of the glovebox gloves obscure polymer material using a inspection light table. The fixture is equipped with a central light supply and small air pump to inflate the glove and test for leak and stability. A glove is affixed to the fixture for 360-degree inspection. Certain inspection processes can be performed:

1. Inspection for pockmarks and thin areas within the gloves.
2. Observation of foreign material within the polymer matrix.
3. Measurements could be taken for gloves thickness using light measurements.

This process could help reduce eyestrain when examining gloves and making a judgment call on the size of material thickness in some critical areas. Critical areas are fingertips and crotch of fingers.

Light Transmission and Air Used For Inspection of Glovebox Gloves

Julio M. Castro, Warren P. Steckle Jr.,
John M. Macdonald, Kennard V. Wilson Jr.
Los Alamos National Laboratory

Introduction

Various materials used for manufacturing the glovebox gloves are translucent material such as hypalon, rubbers, and neoprene. This means that visible light can be transmitted through the inside of the material. Performing this test can help to increase visualization of the integrity of the glove. Certain flaws such as pockmarks, foreign material, pinholes, and scratches could be detected with increase accuracy.

Description

This inspection is performed with the illumination from within the glove by a 300-watt halogen light through a lens. The glove is placed on a fixture where the glove is secured into place with a clamp. Once the glove is secured, a small amount of air is used to inflate the glove to 68.95 mbar (approximately 1 lb/sq. in.). The small amount of air assists in two ways: 1) assists the glove to stand upright for observation and 2) allows the material to stretch for better observation and inspection for possible pinholes.

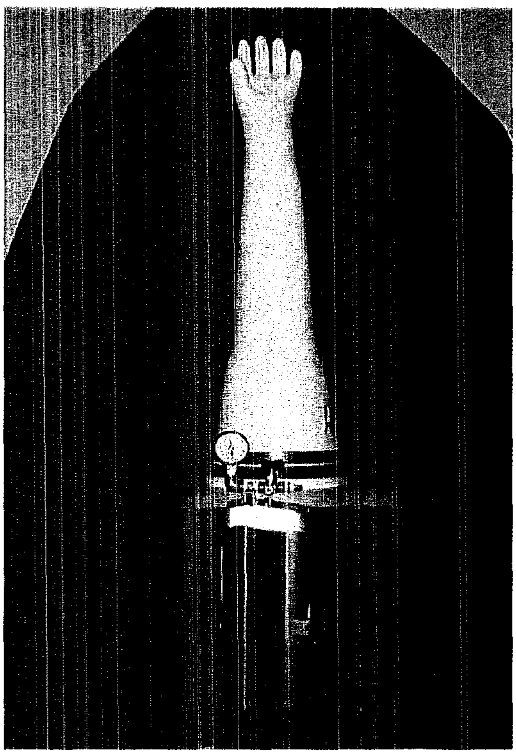


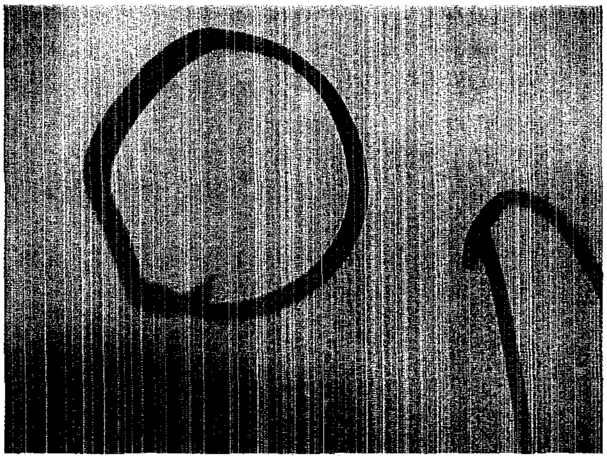
Figure 1

The light energy is affixed to the glove port section of the table. This allows the technician to view the glove 360 degrees for better observation. The light produced from the 300-watt light inside can be measured on the outer surface of the glove with a light meter. The illumination produced from light within the glove is measured. This is used to determine the thickness variation within the glove at different locations, (i.e. finger tip, crouch and palm). The measurement is then taken. A reading from the inside is the difference between the illuminations on the outside. The thickness variation of the glove can be determined by calculating the difference of the illumination of the two locations. The areas are marked with a grease pencil or a marker that is removable. Once the air pressure test is completed, the areas that were suspected to be thin were then gauged.

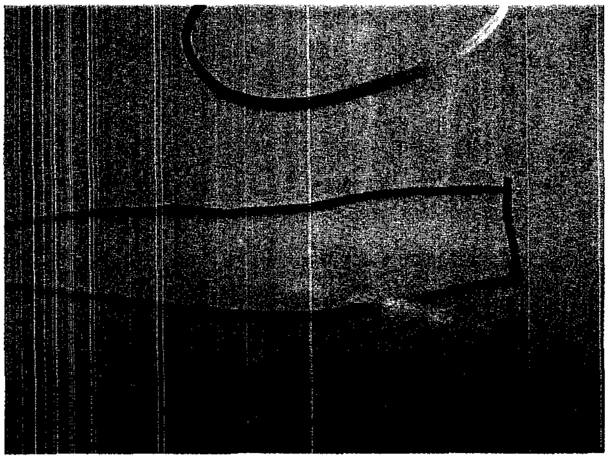
The light also assists in locating imperfections within the glove that could cause glove deterioration. Certain imperfections are embedded material and pock marks. Although some foreign material in small quantities is allowed, there are also areas where a large amounts of foreign material are located that could weaken the structure of the glove.

Quality Control

During visual glove inspections a technician observe and runs his/her hand through the glove to feel for defects within the glove. Although some of the pockmarks may not be so obvious as shown on Figure 2 and 3, these could be weak areas that could cause an exposure concern. The gloves when visually inspected could be over looked or within tolerance. When observed by the light table, insignificant pockmark like Figure 2 and 3 are more obvious. This is further detailed in the "Observation with Light" section of this report.



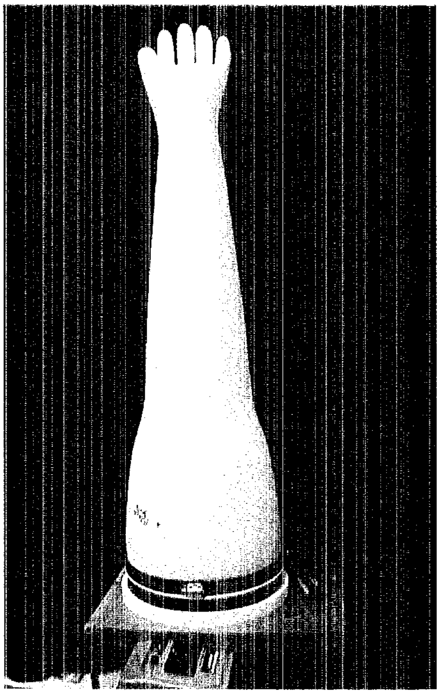
Thin Wall Pockmark
Figure 2



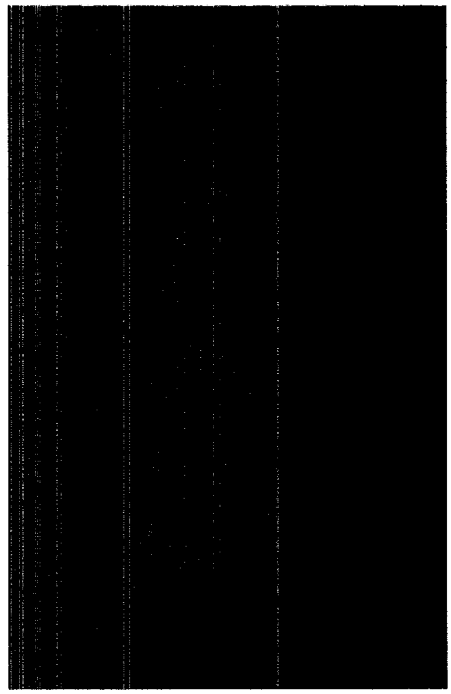
Pockmarks
Figure 3

Glove Illumination

The following are images of a hypalon glove that is illuminated using an inspection light table. The glove shows up with different areas illuminated. These areas are checked with a light meter, marked, and the thickness is then checked with a digimeter. There is no correlation between the thicknesses of the material to the brighter the area on the material.



Glove on Inspection table
Figure 4



Inspection Light On
Figure 5

Front side image of glove

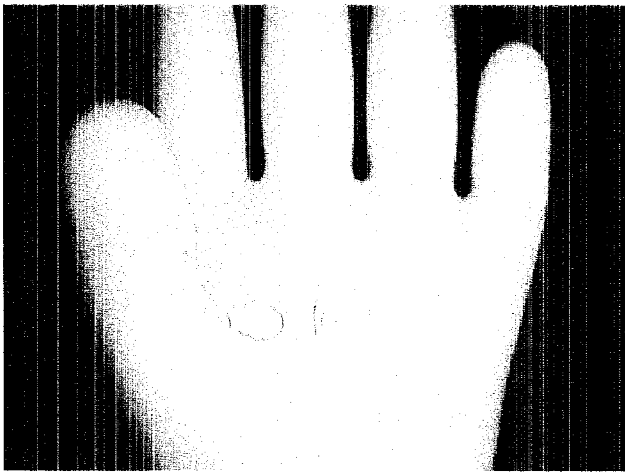


Figure 6

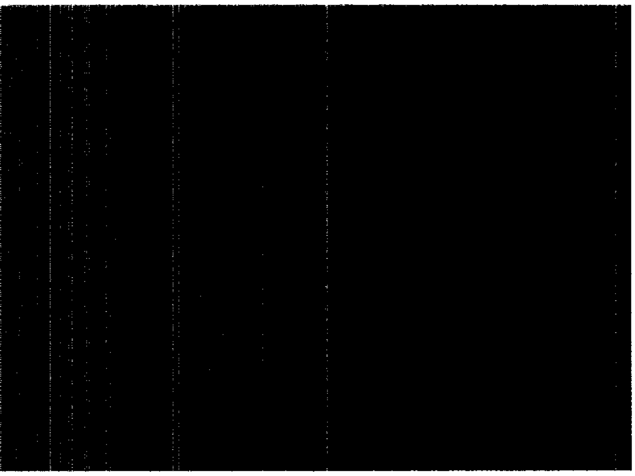


Figure 7

Backside image of glove

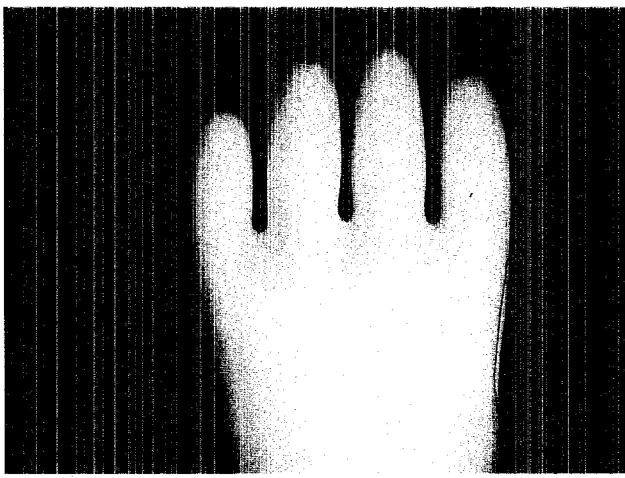


Figure 8

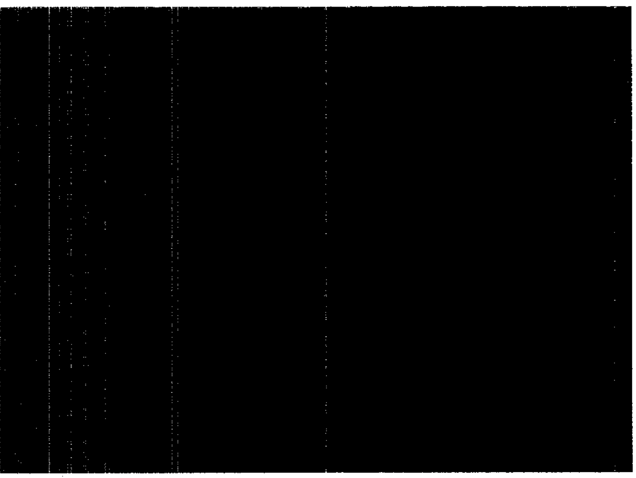
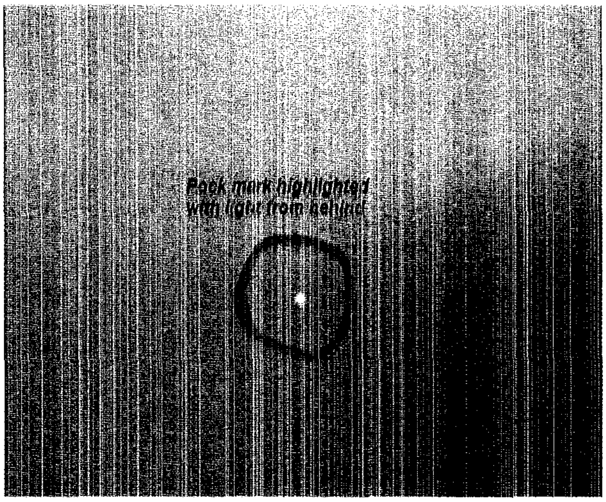


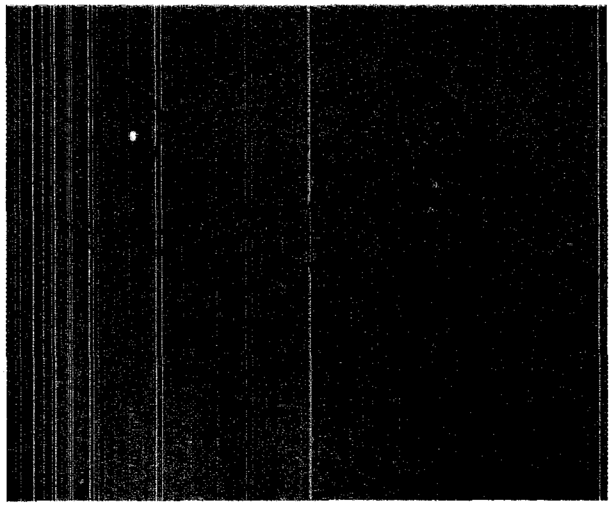
Figure 9

Observation with Light

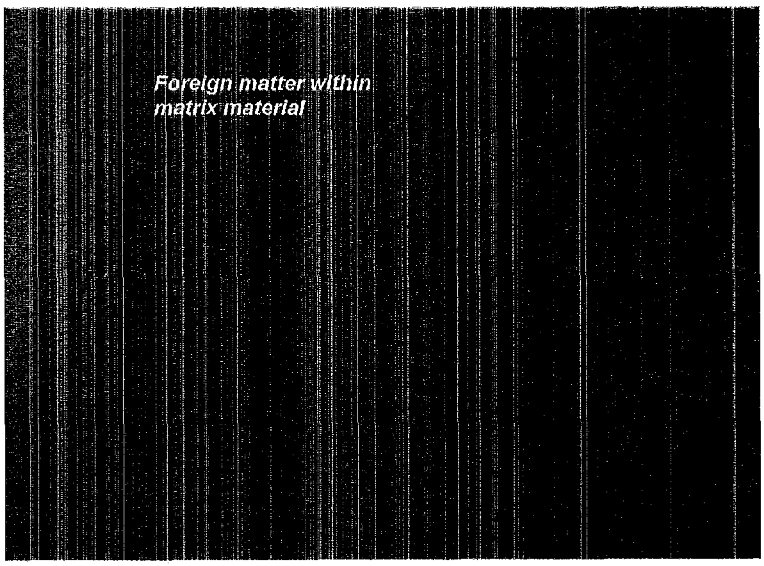
By observing or inspecting the overall glove with a light, the pockmark can become obvious. The figures below show what the pockmarks would look like with the light from the inside of the glove. Although some of the pockmarks may be small and tensile strength may be observed to be higher than normal, these could be vulnerable and prone to weakening when in contact with a harsh working environment (i.e. chemicals, radiation, etc.).



Thin Wall Pock Mark
Figure 10

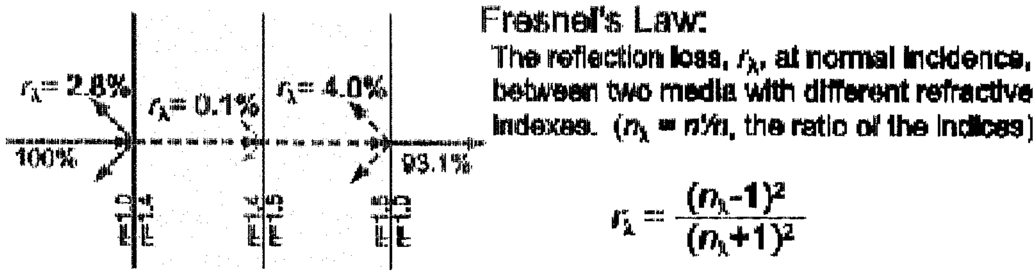


Pock Marks
Figure 11



Embedded Foreign Material
Figure 12

Transmission Losses



Fresnel's law of reflection, showing boundary reflection losses.

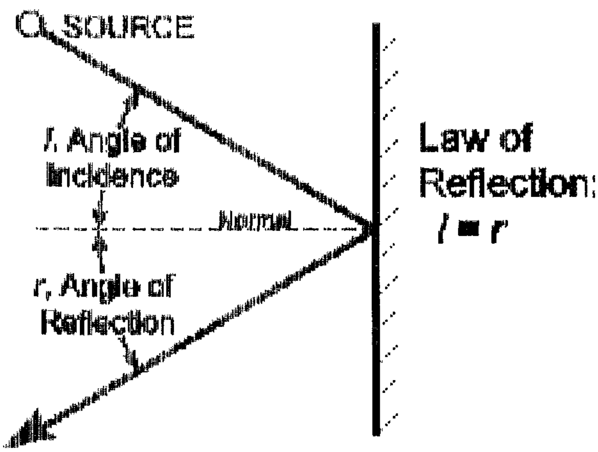
Figure 13

When light passes between two materials of different refractive indices, a predictable amount of reflection losses can be expected. Fresnel's Law quantifies this loss. If n_l = 1.5 between air and glass, then r_l = 4% for each surface. Two filters separated by air transmit 8% less than two connected by optical cement (or even water). Precision optical systems use first surface mirrors to avoid reflection losses from entering and exiting a glass substrate layer.

Reflection

Light reflecting off of a polished or mirrored surface obeys the Law of Reflection: the angle between the incident ray and the normal to the surface is equal to the angle between the reflected ray and the normal.

Precision optical systems use first surface mirrors that are aluminized on the outer surface to avoid refraction, absorption, and scatter from light passing through the transparent substrate found in second surface mirrors.



Law of Reflection

Figure 14

When light obeys the Law of Reflection, it is termed a specular reflection. Most hard polished (shiny) surfaces are primarily specular in nature. Even transparent glass specularly reflects a portion of incoming light.

Diffuse reflection is typical of particulate substances like powders. If you shine a light on baking flour, for example, you will not see a directionally shiny component. The powder will appear uniformly bright from every direction.

Many reflections are a combination of both diffuse and specular components. One manifestation of this is a spread reflection, which has a dominant directional component that is partially diffused by surface irregularities.

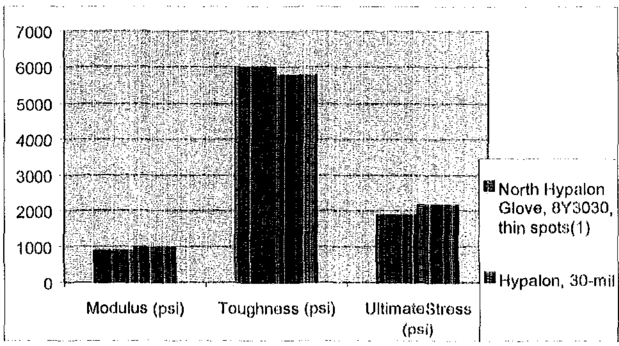
Pockmark

Pockmarks are formed by air pockets within the mold and material matrix when the molds are dipped into the material. Occasionally pockmarks can also be developed by dirt or foreign debris on the molds. Pockmarks would increase normal tensile strength for the glove by 5-10%, but with hazards such as radiation and chemicals introduced to the equation this could decrease the longevity of the glove by 15-20%.

Sample File	Sample Description	Number Pulled	Time (days)	Modulus (psi)		Toughness (psi)		Ultimate Stress(psi)		Ultimate Strain(in/in)		Thickness (in)	
NY30THIN	North Hypalon Glove, 8Y3030, thin spots(1)	5	N/A	876	±73	5991	±311	1874	±67	6.44	±0.15	0.0301	±0.0007
					±		±		±		±		±

N/A = not applicable, samples stored and tested at room (ambient) temperature; no aging performed
(1) No samples failed at the thin spot.

Sample File	Sample Description	Number Pulled	Time (days)	Modulus (psi)		Toughness (psi)		UltimateStress (psi)		Ultimate Strain(in/in)		Thickness (in)	
HYP15M	Hypalon, 15-mil	10(7)	N/A	972	±64	6559	±424	2551	±137	5.57	±0.13		±
HYP30M	Hypalon, 30-mil	10(8)	N/A	960	±87	5763	±242	2157	±111	5.34	±0.10		±



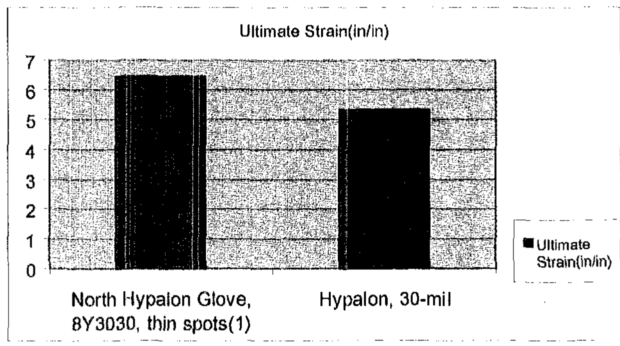


Figure 15

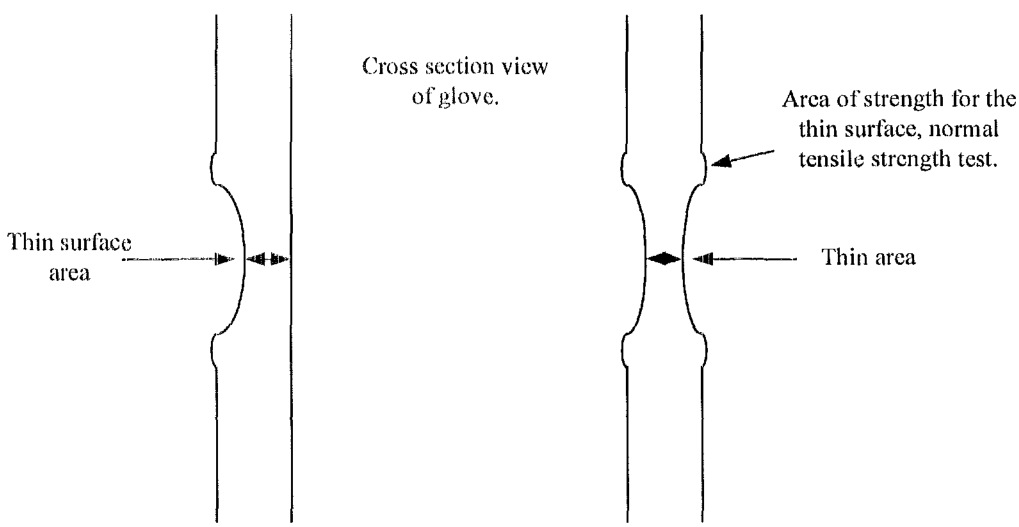
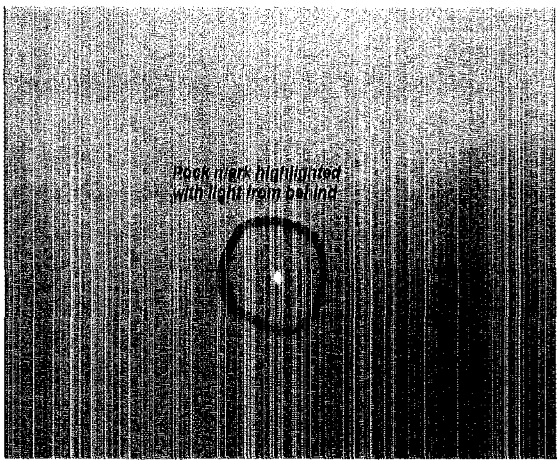


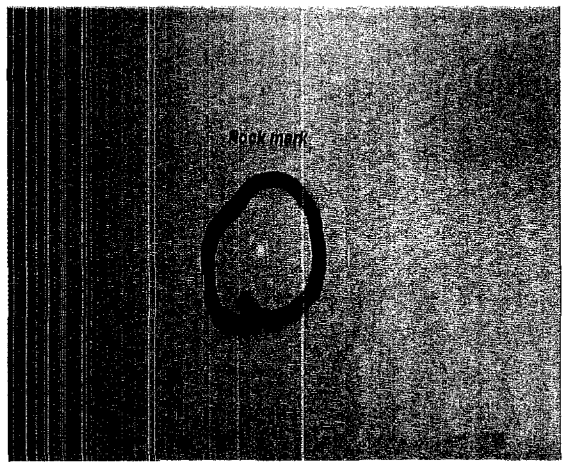
Figure 16

Non-Destructive Glove Evaluation

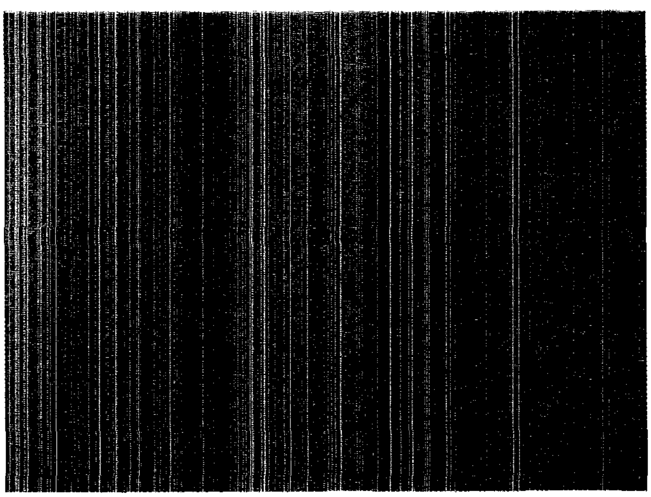
Based on some of the initial tests conducted with an incandescent lamp, we were able to see embedded foreign material within the polymer, as seen below in Figure E. Some of the embedded material is from un-dissolved or residual polymer material such as butyl rubber. Although we were not able to see or inspect the finger areas with the first generation light, with the projector light, we were able to observe the entire glove and fingers. Each one of these methods had a drawback, but in evaluating each one, we have been able to progress to a more reliable method. Pockmarks or thin areas within the polymer surface were also observed within the glove. Pockmarks can be difficult to observe or measure. These small areas are, and can be, a region of fatigue when they come into contact to chemicals and radiation.



Thin Wall Pock Mark
Figure C



Pock Marks
Figure D



Embedded Foreign Material
Figure E

Pockmarks or thin areas within the polymer surface can be difficult to measure with standard calipers or micrometers. Manufactures use calipers called deep throat digimatic thickness gauges. The thickness gauge have two ¼" flat round plates that make contact with the material, which is equivalent to 0.1963 square units. Because a thickness gauge cannot be used to measure the depth of pockmarks, it is necessary to introduce another method of inspecting gloves for thin area and looking for glove weaknesses. This is why we should consider or evaluate the use of light as one of the inspection tools or standard for inspecting the gloves.

Question and Issues

Based on the observation of the two different products some question and issues come to mind:

- Gloves product are observed with striations and dark areas thicker than the lighter areas?
- Does more light mean thinner material?
- Are the lighter areas weaker then darker areas?
- Do the gloves product opaque areas mean more filler?
- Does this make the area stronger, or weaker?
- Could this mean a problem in the QA of the batch?
- Is the viscosity of the batch compromised when more batch mix is added to the tank?
- Are these a problem with the mixing of the material?
- Is the mixing process to slow? Or to fast?
- What about temperature?
- Are certain products not combining with others like they should? Why?

Thickness Instrument

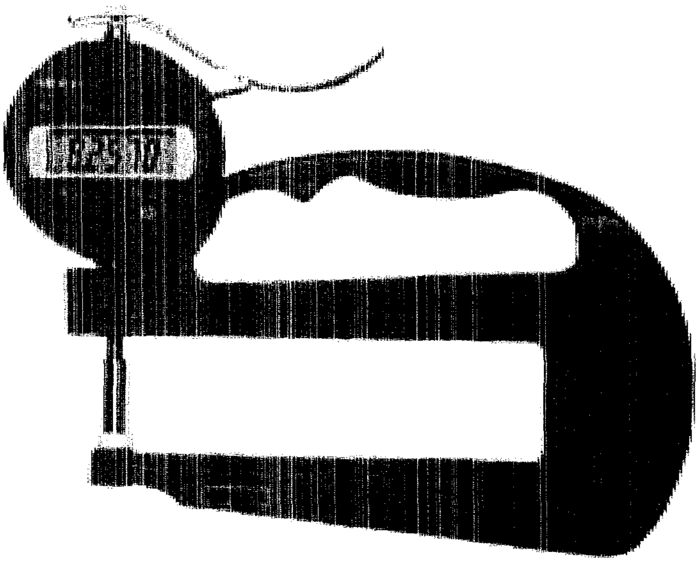


Figure 17

List of parts

1. Projector
2. Plate table
3. Pressure gauge
4. Pressure regulator
5. Light sensors – one outside

ACKNOWLEDGMENTS

The authors wish to thank the following people for their support in the design of the Light inspection table; Dona Peterson, Budgeting, BUS-2, McIlwaine Archer III, Material, Science and Technology, MST-7 and Richard D. McLellan, NMT-5, TA-55 Machine Shop.

References

Light Measurement Handbook © 1997 by Alex Ryer

Light Transmission and Air Used for Inspection of Glovebox Gloves

Julio Castro, HSR-1

Health Physics Operation

John Macdonald, NMT-10

Process Engineering

Warren Steckle Jr., MST-7

Polymers/Coating

Kennard Wilson, MST-7

Polymers/Coating

August 2002 AGS Conference

LA-UR-02-5164

Procurement Specs

- Procurement specs identify thickness measurements to be:
  - $8X^{A}1530$ to be 0.015
  - $8X^{A}3030$ to be 0.030

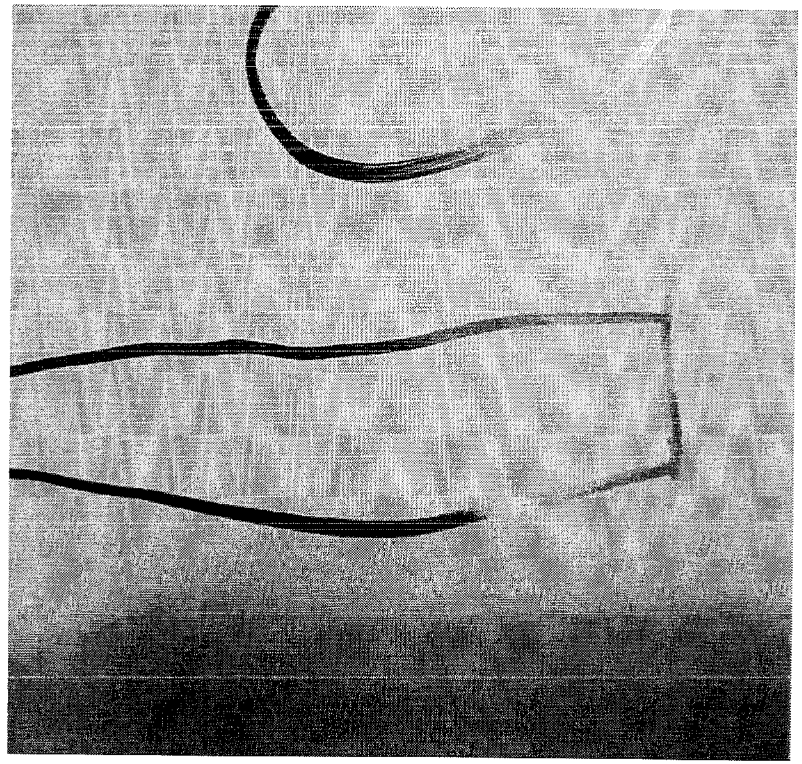
X^{A} = identifies any translucent product

Current Procedures

- Inspections are performed by a person running their hand through the glove feeling for obvious imperfections within the glove.
- Some physical measurements are taken within certain areas of the forearm area.
- No measurements are performed within the hand area.
- Pockmarks are not measured for thickness.

Quality Control

- Inspections are performed by feeling the glove for imperfections and observing for defects.
  - Imbedded foreign material
  - Small indentations
  - Cuts
  - Scrapes
  - Pockmarks
  - Thin spots
- Imperfections could be on both sides of the material, but only one side is inspected.



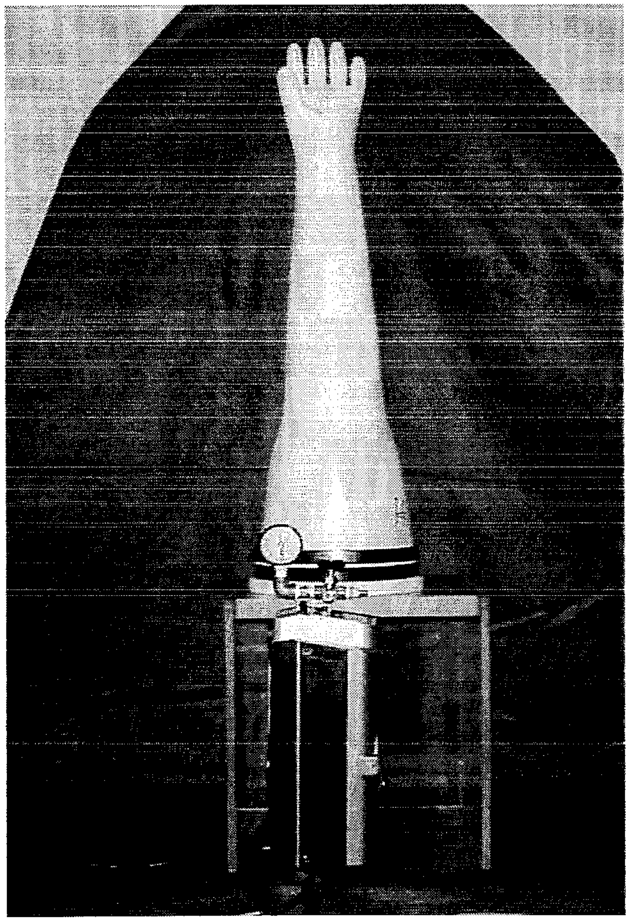
Quality Control

- Large imperfections are inspected and measured.
- Measurements are taken with a thickness gauge.
  - Two ¼" plates with a surface area of 0.1963 square units.
- Small indentation or pockmarks are acceptable?
- Foreign material within the polymer is of no concern.

Recommendations

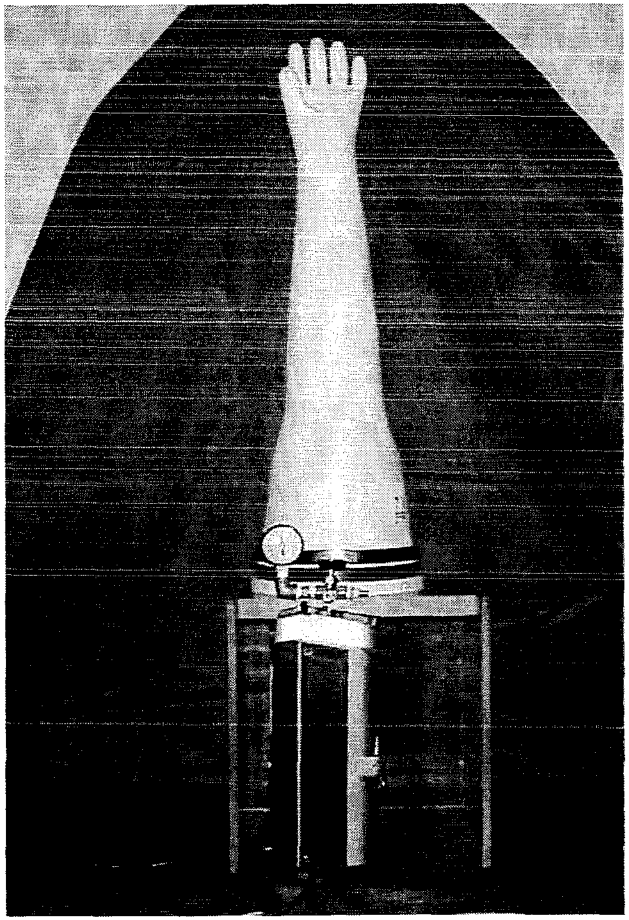
- Recommend that the use of light be considered as part of the inspection criteria for the glovebox gloves. This light will make the overall glove visible and could pinpoint problem areas.

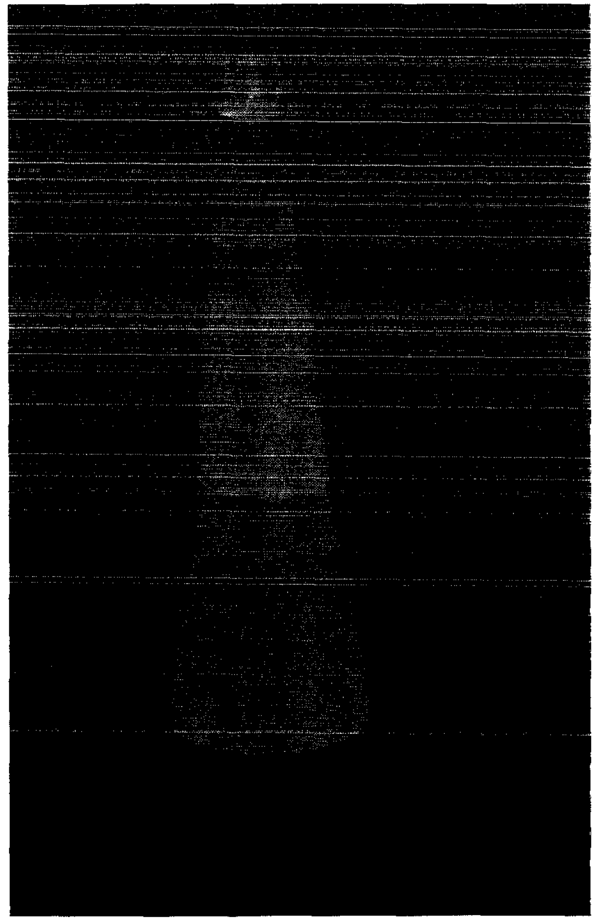
Inspection Table



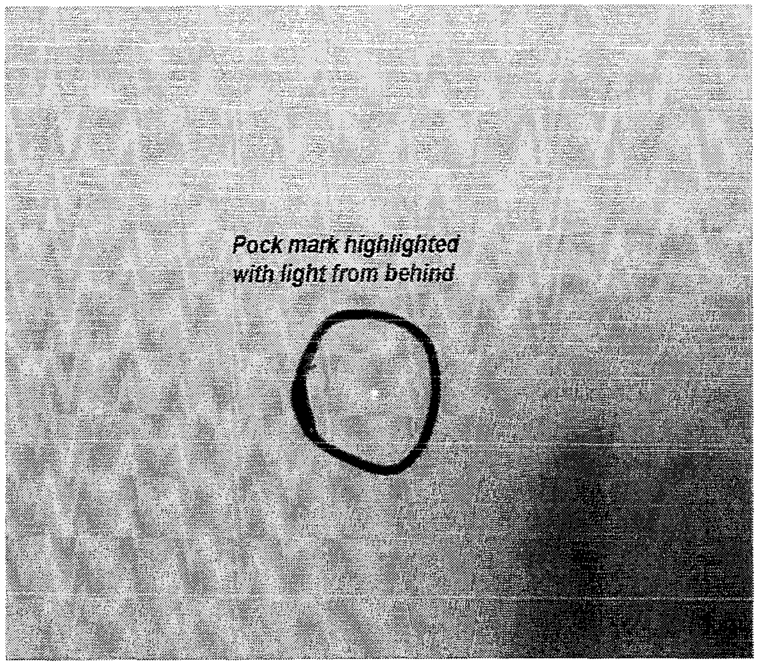
- Light inspection table with 300 watt light.
- Table rotates 360 degree for observation.
- Small air pump for inflation testing.

Inspection Table





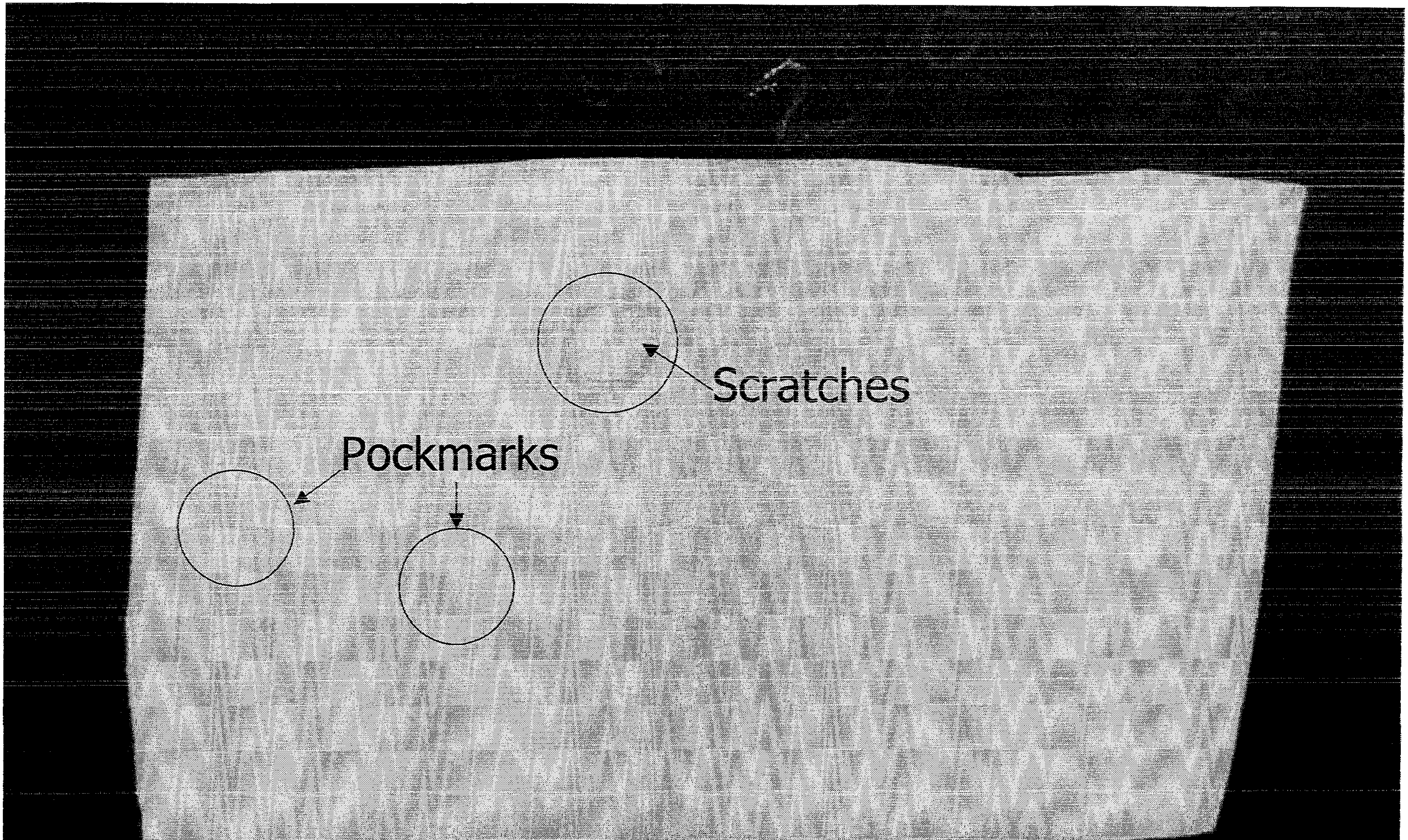
Inspection Table



- Pockmarks may be small and tensile strength may observe higher than normal sections of material. These could be vulnerable and prone to be weak areas when in contact with the harsh working environment they come in contact with (i.e. chemicals, radiation, etc.).
- Light for only translucent material.

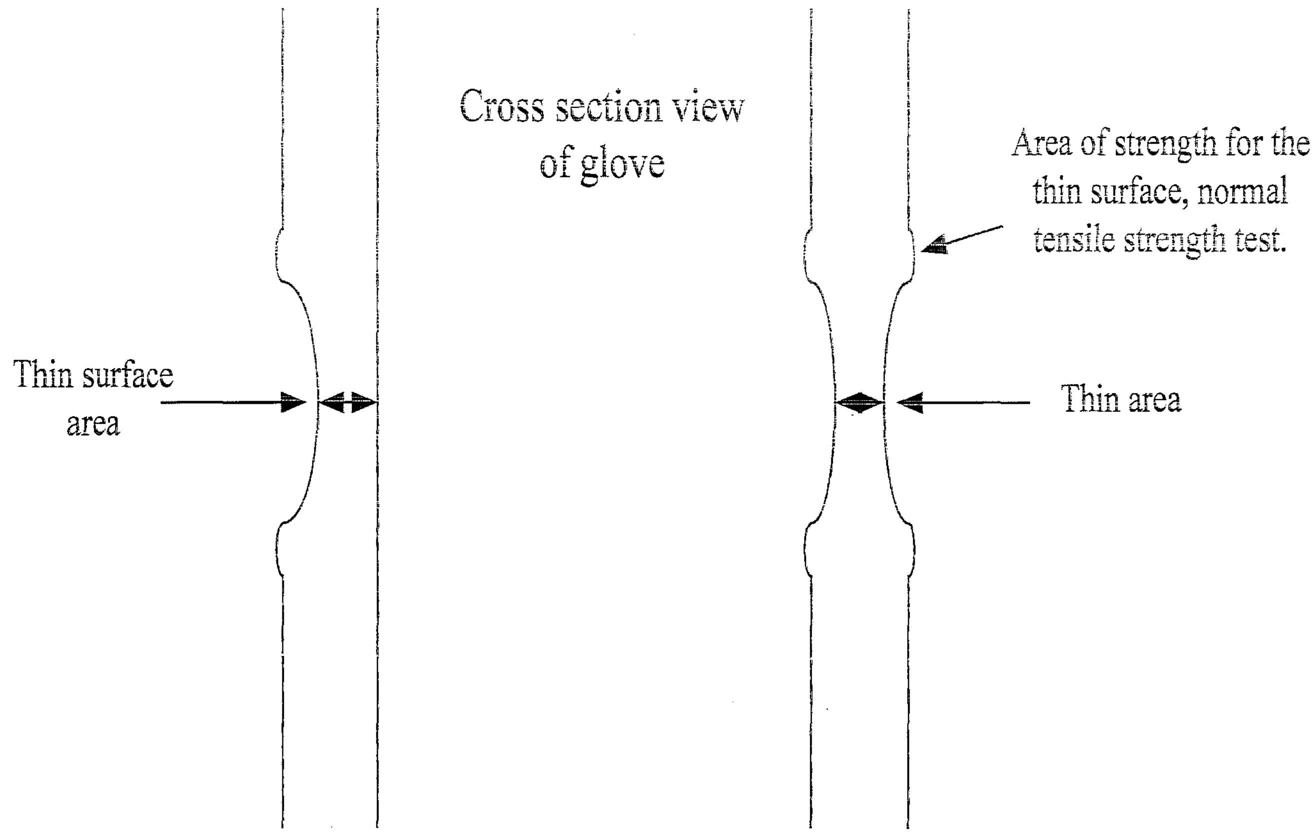
X-ray Observation

- Pockmarks and scratches are not only visible on hypalon gloves.
- Pockmarks can be visible on lead load glovebox gloves.



E

Inspection Table

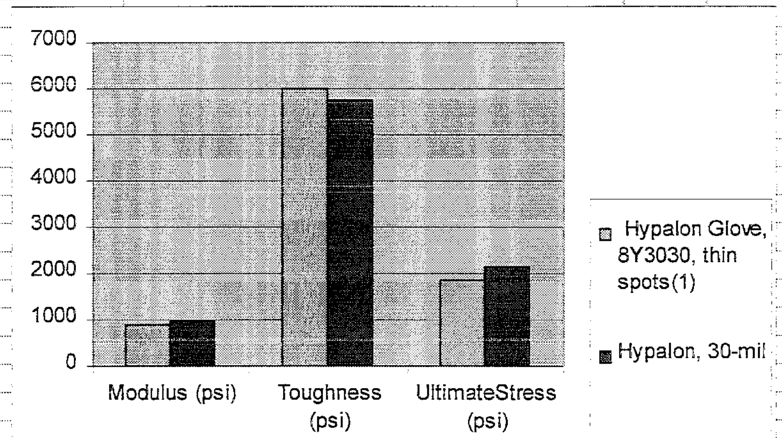


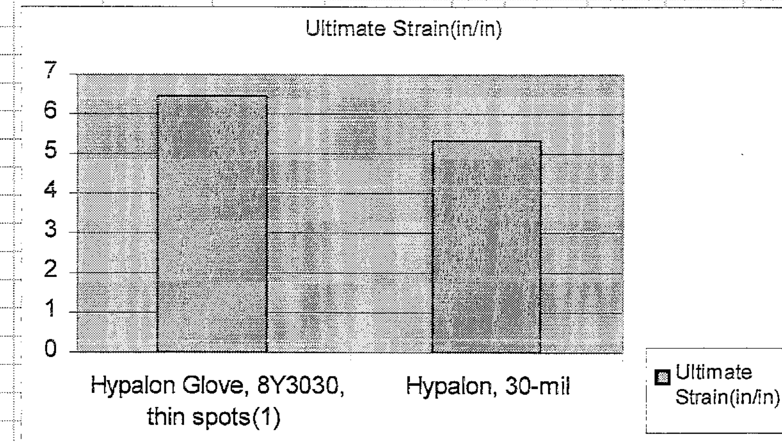
Pockmark Test

Sample File	Sample Description	Number Pulled	Time (days)	Modulus (psi)		Toughness (psi)		Ultimate Stress(psi)		Ultimate Strain(in/in)		Thickness (in)	
NY30THIN	Hypalon Glove, 8Y3030, thin spots(1)	5	N/A	876	±73	5991	±311	1874	±67	6.44	±0.15	0.0301	±0.0007
					±		±		±		±		±

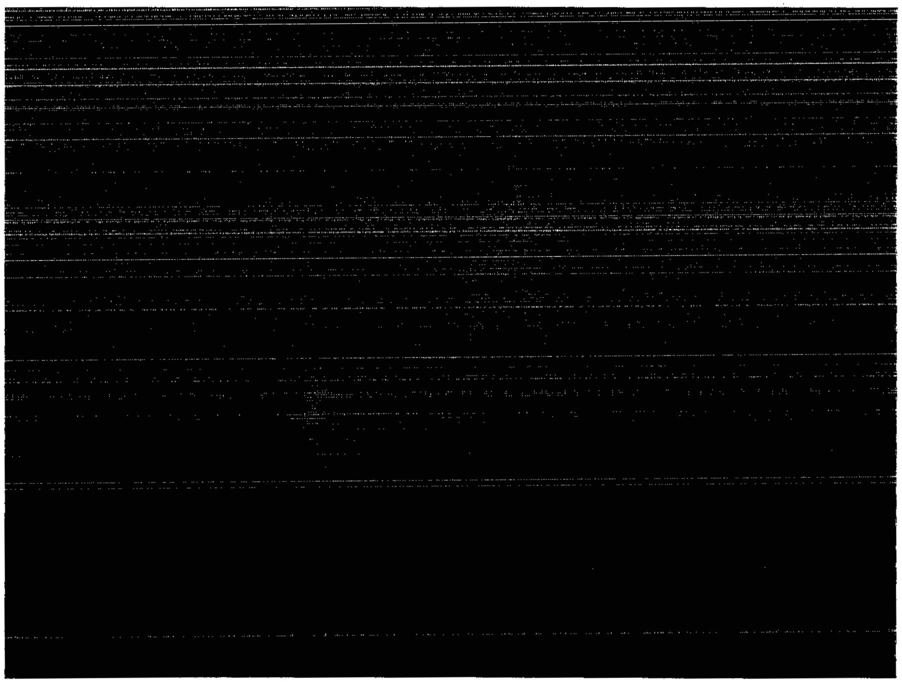
N/A = not applicable, samples stored and tested at room (ambient) temperature; no aging performed
(1) No samples failed at the thin spot.

Sample File	Sample Description	Number Pulled	Time (days)	Modulus (psi)		Toughness (psi)		UltimateStress (psi)		Ultimate Strain(in/in)		Thickness (in)	
HYP15M	Hypalon, 15-mil	10(7)	N/A	972	±64	6559	±424	2551	±137	5.57	±0.13		±
HYP30M	Hypalon, 30-mil	10(8)	N/A	960	±87	5763	±242	2157	±111	5.34	±0.10		±



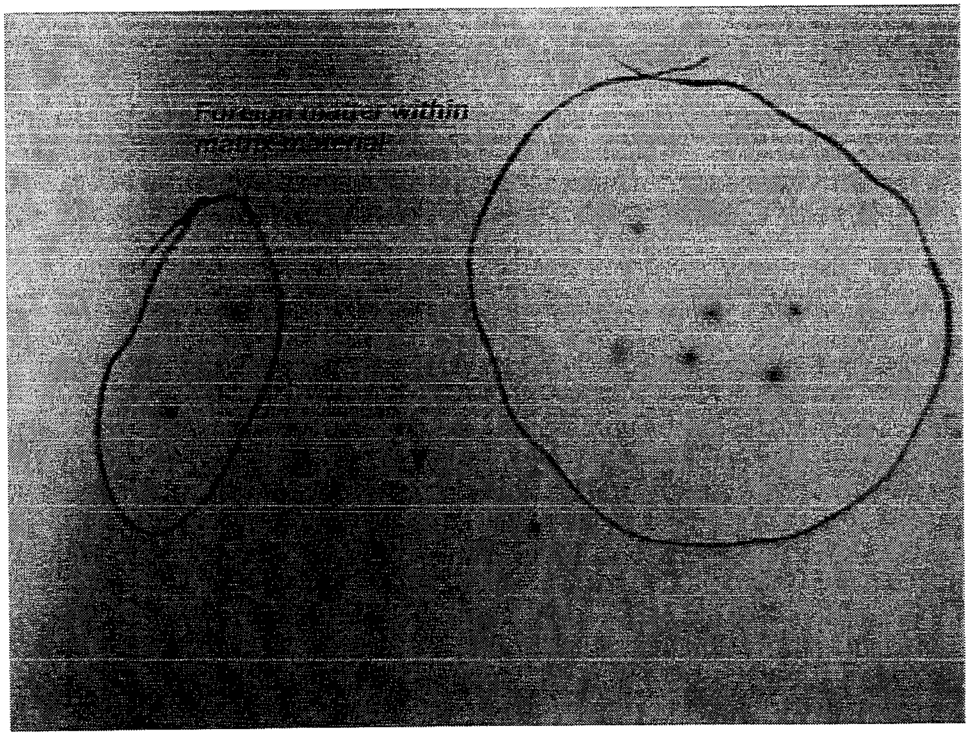


Inspection Table Analysis



- When the light is projected into the glove the thin areas are illuminated and can be measured:
  - Is this true? Are there thinner areas? Or are they areas with less opaque material?
  - Does this make the material weaker?

Inspection Table Analysis



- Embedded foreign material within polymer, seen in the figure.
- How much foreign matter within the glove is safe?

Analysis

- Products observed with striations and dark areas.
- Are these dark areas thicker than the lighter areas?
- Does more light mean thinner material?
- Are the lighter areas weaker than darker areas?
- Do other products with opaque areas mean they have more filler?

Analysis

- Does this make the area stronger, or weaker?
- Could this mean a problem in the QA of the batch?
- Could there be a problem with the mold?
- Is the viscosity of the batch compromised when more material is added to the tank?

Analysis

- Is this a problem with the mixing of the material?
- Is the mixing process too slow? Or too fast?
- Is the dipping of the mold to fast.
- Are certain products not combining with others like they should?

Recommendations

- Light and air be considered for inspection.
- Gloves be marked as tested.
- Pursue funding resources on both sides.
- More communication and visits for QA of manufacture sites.
- More focus ASTM standards toward glovebox gloves.

Better gloves means less incidents,

less down time

and

more productivity,

which means,

Less Wasted Issue.